10-7-2011

Instructional Practices for Teaching Systems Concepts

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by Dario Nardi, UCLA, October 2011

Agenda

Systems concepts such as attractors, bifurcation, chaotic behavior, emergence, iteration, multi-agency, networks, nonlinearity, may be hard to grasp, even after a lecture or demonstration. How might we more effectively convey systems concepts?

1. Live group simulations
2. Diffusion of trait-based memes
3. Nonlinear training

Practice #1

- Live group simulations promote learning of systems concepts and multi-agent behavior.
- An activity might involve as few as ten participants or 150+ and last from 10 minutes to several weeks.
- Students receive reading material.
- We do pre-briefs and debriefs.
- In general I am hands-off to let the system evolve.
- Let's explore 3 examples.

A 10-Minute Activity

This activity relies on a simple algorithm where students sit and stand in class based on certain conditions.

- “Let’s start by half of us sitting or standing.”
- “Pick 1 other person in the room and a rule to follow: either you a) match that person’s behavior or b) you mismatch it (sit it their sitting, etc).
- “We will go in quick 2-minute turns. We’ll repeat the experiment several times and discuss.”
- During debrief: “Notice the frozen, cyclical or chaotic pattern that emerges.”

90-Minute Activity

We go outside. Students follow a rule or rule. I may segment the activity into 10-minute iterations.

Example Rule-Set

- **Science** – Each turn you may ask me 1 general question or 2 specific investigative questions.
- **Military** – Each turn you may detain 2 participants or "kill" 1 participant (remove your fellow student from the simulation).
- **Business** – Each turn you may allow one group to use its special ability twice normal, or you can "invest" by hiring 3 citizens who produce a new prop for you (request one prop from me).
- **Government** – Each turn you may command another group to exercise its special ability to your liking.
- **Religion** – Each turn you may pray for divine intervention to reverse the effects of another group's special ability (inform me of your prayer).
- **Media** – Each turn you may visit any other groups as often as you like to gather information, and I may ask you to make general announcements to the whole class between turns.
- **Medicine** – Each turn you can either administer a medicine you have to 5 ill people or you may instead develop a new medicine targeting a new illness.
- **Citizen** – By majority vote amongst yourselves, you can replace two persons from government with two of your members.
- **Immigrant** – You may petition a group to join it. If you are accepted then you gain their special ability.
- **Rebel** – You don't play by any rules!

Debriefing the Activity

Typical patterns even as each simulation generates a unique historical path.

1. How aware were you of what others were doing?
2. What prompted you to act or make a choice, and when? How often did you feel uncertain, and how did you decide when uncertain?
3. How aware were you of the results of your actions?
4. Did you behave as “you” in real life or do things you wouldn’t otherwise do?
5. How might have information traveled through the community?
6. How much could someone understand or influence the community as a whole?
7. In what ways might (you) agents have tried to learn or adapt?
8. How did so much happen when the rules (turns, roles) are so simple?

Multi-Agency Revealed

Match the simulation elements on the left with the multi-agent concept on the right.

- **Modeler** = The course instructor
- **Agents** = Students such as yourself
- **Rule-Set** = Instruction sheet
- **Environment** = The grassy, tree-lined quad outside the classroom
- **Props** = Water guns, cookies, and tennis balls
- **Iterating** = 10-minute turns
- **Memory/Mental-Models** = Participants draw upon past simulation experiences
- **Exogenous Influence** = Note cards from instructor with special instructions
- **Payoff/Fitness Criteria** = Students gain extra credit

4-Week Tavistock Activity

Each group of 6 to 8 students has this abstract task:

"Please give a 15-minute group presentation on your group's process while preparing to give that presentation."

- They regularly meet in their own room.
- They read about group dynamics on their own.
- I intervene minimally by giving reflective nudges.
- They shall not use electronic technology.

Group Culture Emerges

Each group develops a set of shared stories, models, norms, practices, values, expectations... that emerge from overcoming their struggles.

Practice #2

How might we accurately and simply model the diffusion of information through a social system? We can model the diffusion of trait-based memes through multi-agent friendship networks.

Classic Diffusion: Assumes a homogeneous population and relies on a single equation of growth with a coefficient.

Example: # of new people = alpha * (Total population – # who know) ; where alpha = 0% to 100%

Multi-agent Diffusion: A simulation affords a heterogeneous population where some agents are more or less likely to notice, accept or share a meme. The multi-agent approach reproduces real-world oddities in diffusion.

Question: What about the meme itself? How can we tweak memes to make them more/less palatable?

Faceted Meme Diffusion

- The simulation generates a large population of heterogeneous agents with traits based on demographic trends.
- The simulation links agents into friendship networks based on percentage trait compatibility. The more traits in common, the more likely they'll be friends; or alternatively, the user defines threshold of compatibility.
- The user introduces a set of memes, each meme is characterized in terms of the agents' own traits, with the percentage likelihood that agents share and/or accept memes handled as a function of their percentage compatibility.

Spawning Heterogeneous Agents

```
// Trait #5: Pregnant? True or False
// Assume average 8.7% chance for woman age sixteen to forty-one.
// Over a 25-year period, an American woman produces 2.1 children.
x = random(1000);
if(sex.equals("female") && age >= 16 && age <= 41) {
                if(ethnicity.equals("European")) y = 81;
                else if(ethnicity.equals("Hispanic")) y = 121;
                else if(ethnicity.equals("African")) y = 84;
                else if(ethnicity.equals("Asian")) y = 81;
                else y = 73;
                if(x <= y) pregnant = "true";
                else pregnant = "false";
                }
else pregnant = "false";
```

Forming Friendships

```
// populate roster with 10,000 agents
    for(i = 0; i < 10000; i++) roster[i] = new Citizen();
// get compatibility threshold from the user
    text = JOptionPane.showInputDialog("Please enter friendship threshold (0% to 100%):");
    threshold = Integer.parseInt(text);
// construct social network, where: true = agents are friends, or false = agents are not
    for(i=0; i< 10000; i++) {
       for(j=0; j< 10000; j++) {
                        c = roster[i].compareWith(roster[j]);
                        if(c >= threshold) network[i][j] = true;
                        else network[i][j] = false;
                        }
       }
```

Crafting Competing Memes

```
// target of "pro-choice" meme (start ProChoice = 0)
        if(agent.sex.equals("female")) ProChoice++;
        if(agent.pregnant.equals("true")) ProChoice++;
        if(agent.politics.equals("left-wing") || agent.politics.equals("liberal")) ProChoice++;
        if(agent.religion.equals("agnostic") || agent.observance.equals("never")) ProChoice++;
// target of "pro-life" meme (start ProLife = 0)
        if(agent.sex.equals("female")) ProLife++;
        if(agent.pregnant.equals("true")) ProLife++;
        if(agent.politics.equals("right-wing") || agent.politics.equals("conservative")) ProLife++;
        if(!agent.religion.equals("agnostic") && agent.observance.equals("weekly")) ProLife++;
// resolve agent's opinion
        if(ProChoice == 0 && ProLife == 0) opinion = "neutral";
        else if(ProChoice >= ProLife) opinion = "pro-choice"; // break in favor of what is already legal / sanctioned
        else opinion = "pro-life";
```

Diffusion Over Time

Results of run #1

- Pro-choice citizens = 47%
- Pro-life citizens = 40%
- No opinion citizens = 12%

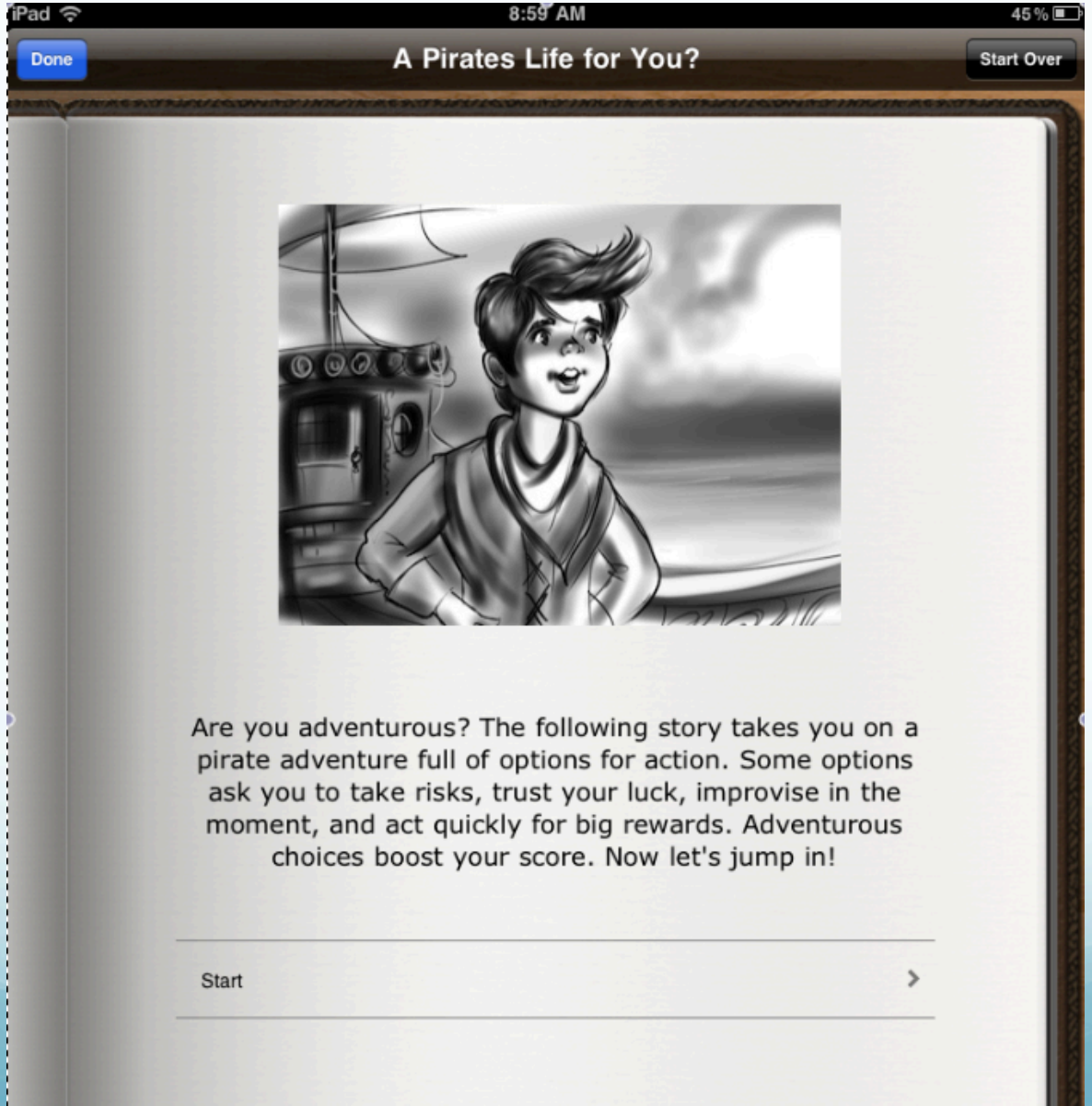
Results of run #2

- Pro-choice citizens = 44%
- Pro-life citizens = 45%
- No opinion citizens = 9%

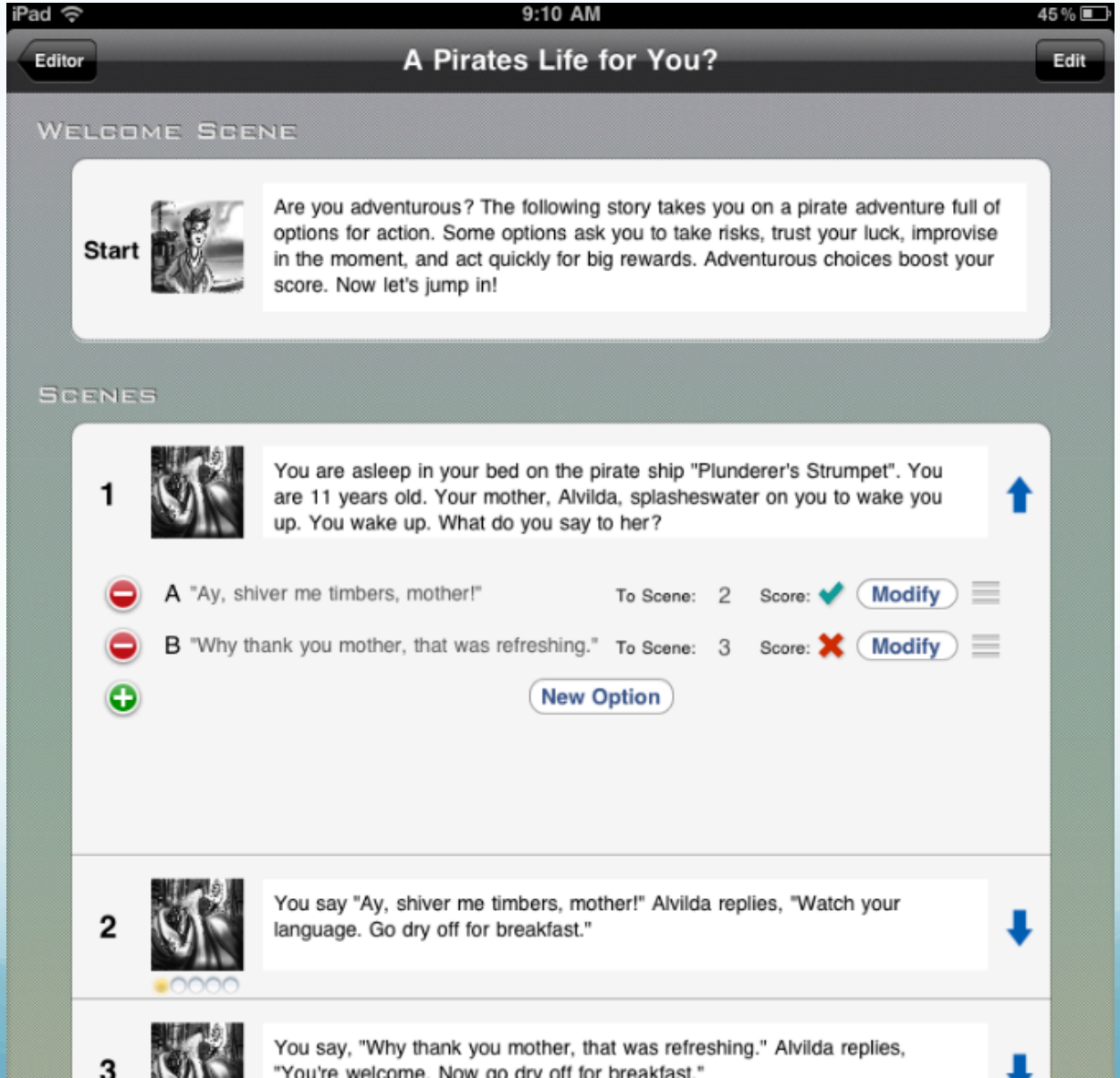
Practice #3

- I help students design nonlinear training scenarios to assess decision-making capabilities in context.
- Engaging learners in a design process often asks them to consider questions they might miss in a traditional learning environment.
- Design also helps students internalize material and help them “reality test” their ideas.
- Although engineering and fine arts students are used to design, students from physical and social sciences and humanities are often not. How can we engage them to internalize design concepts?

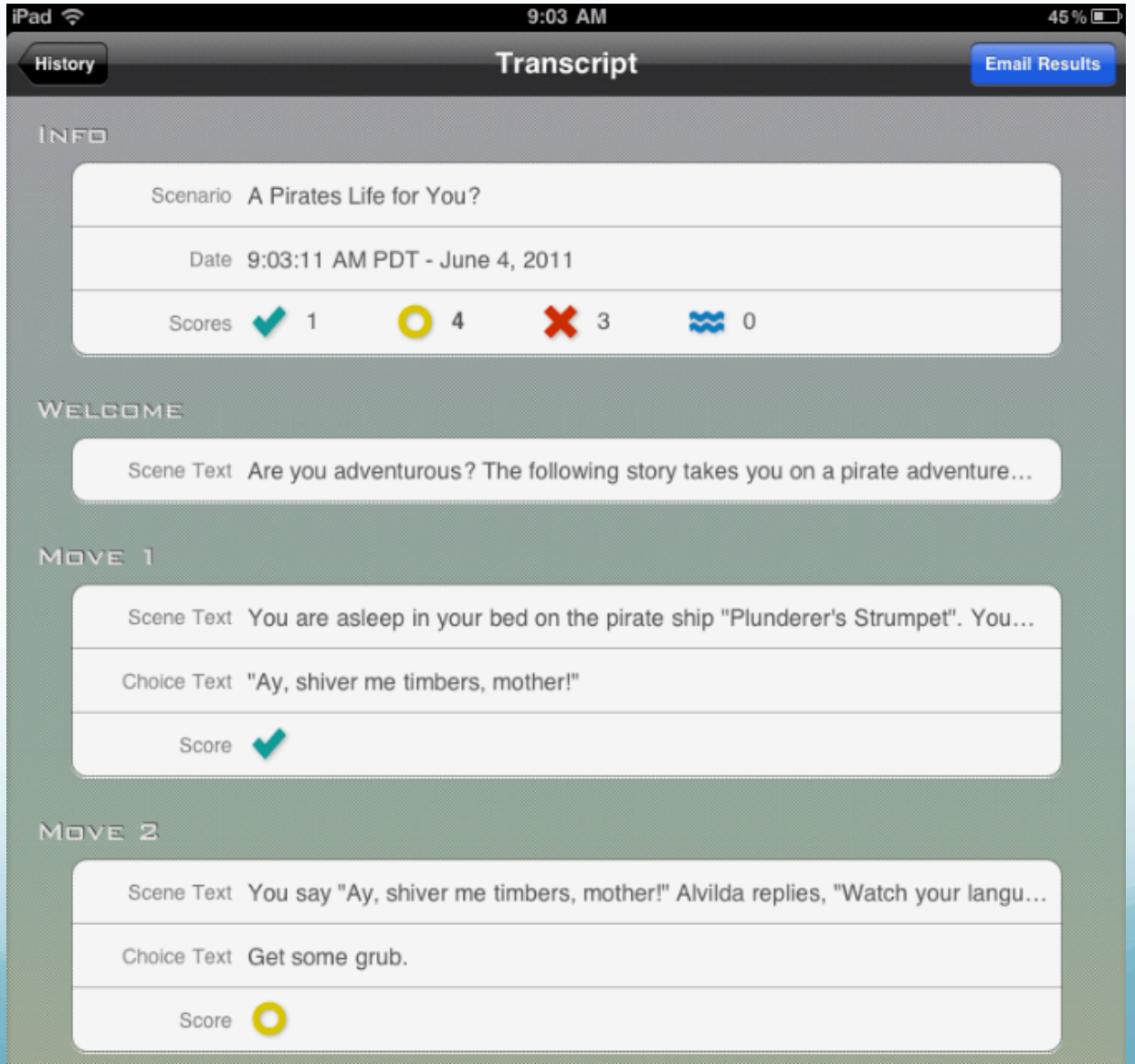
Training Scenarios



Branching Options



Scored Feedback



The Design Process

Design often invokes many questions.

- What tangible goals are we striving to meet?
- What resources do we need, and how to qualify or budget resource use?
- Who is using the resulting design? And how well will the result work for them?
- How might we solicit and integrate feedback?
- What is our creative process to ensure a best possible result? Are there best-practices and reliable principles?
- More questions....

Where From, Emergence?

Observation: Emergence of expected, interesting behaviors and patterns tend to occur more in some activities than others.

Conjecture: Emergence occurs most in multi-agent systems located in a space (physical or virtual) that involves boundaries, props, and movement.

Questions?

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